BACTERIOLOGICAL CORROSION IN WATER
BIO-FILM:
WHAT IS A BIO-FILM? AND HOW TO CONTROL IT!

Presented By:

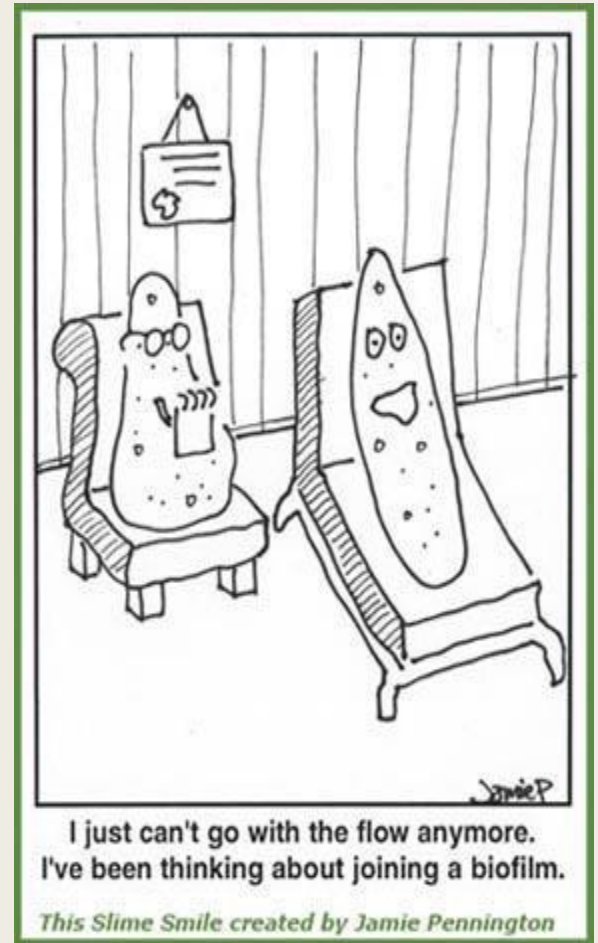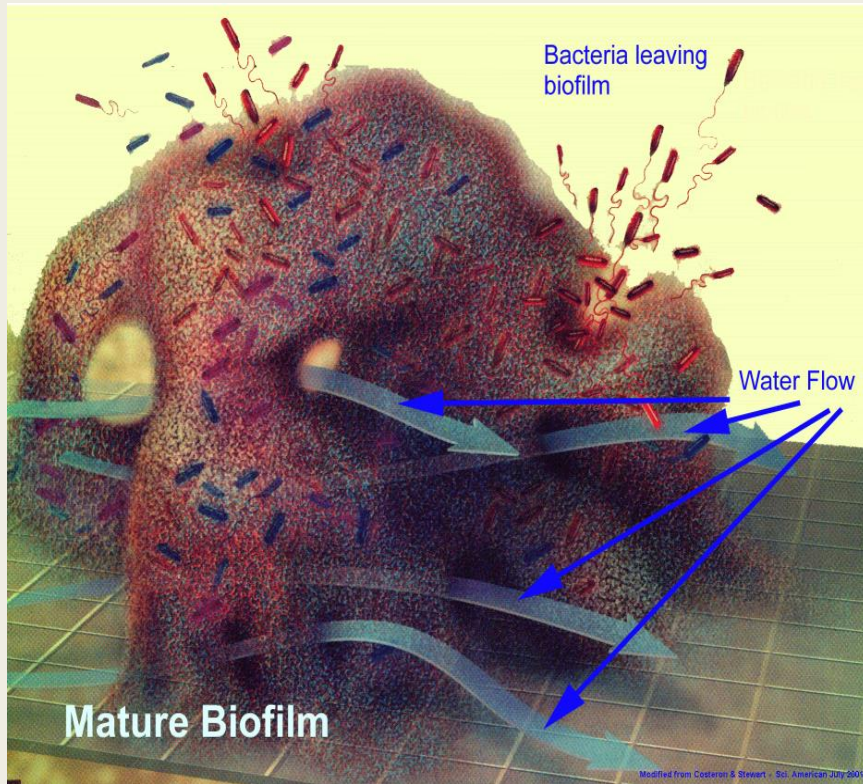Corey Harper

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BIO-FILM


Mature Biofilm

Bacteria leaving biofilm

Water Flow

Modified from Costeron & Stewart · Sci. American July 2001

I just can't go with the flow anymore.
I've been thinking about joining a biofilm.

This Slime Smile created by Jamie Pennington

BIO-FILM 101

- Definition of a Bio-Film:
- Where does it come from?
- Names of Bio-Film.
- Recognizing types of Bio-Films.
- Bio-Formations
- Testing for Bio-Films
- CAUSE and EFFECT of Bio-Films in Systems/Plants
- Developing a Plan to FIGHT Bio-Films
- Monitoring Bio-Film RE-GROWTH

BIO-FILM Definition:

HAWKINS

■ **Bio-films** are the accumulations of microorganisms (e.g., bacteria, fungi, algae, protozoa, and viruses) and organic and inorganic matter bound by extra-cellular polymer substances (EPS) attached to the inner surfaces of pipe and storage tanks in water systems.
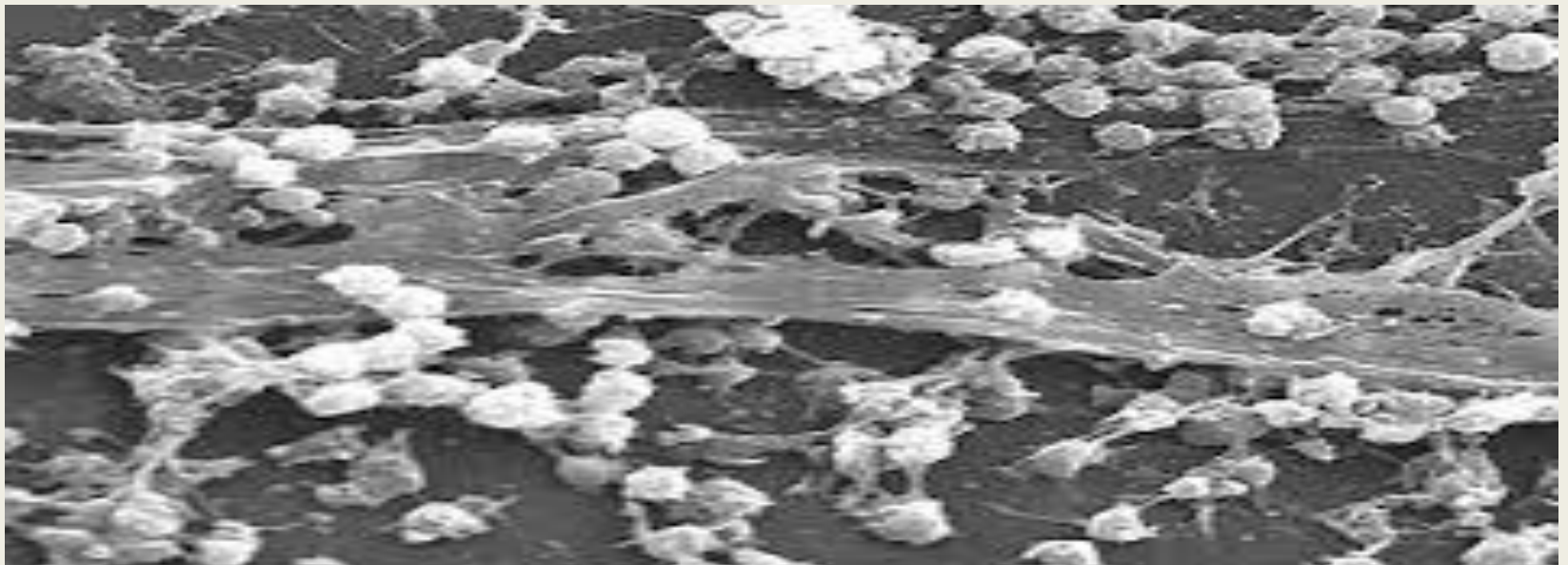
Where does a BIO-FILM come from??

■ **Bio-Film** originates from a variety of sources of organic compounds. (bacteria, algae, fungi, viruses, protozoa).

■ Source water from plants have these present Before, During, and after Treatment.

■ Treatment removes or kills most of the Organic Compounds.....However, some pass through treatment

■ EVERY PLANT and DISTRIBUTION System contains a presence of these Bacteria.

■ WTP's vs. Distribution vs. Consecutive (Purchasing) systems

  ■ Who's Responsible??????? _NONE_ are responsible for presence

  ALL are responsible for fighting it

  "TOGETHER"

Where does a Bio-Film come From??

■   Micro-organisms/Bacteria can enter through 2 main areas:
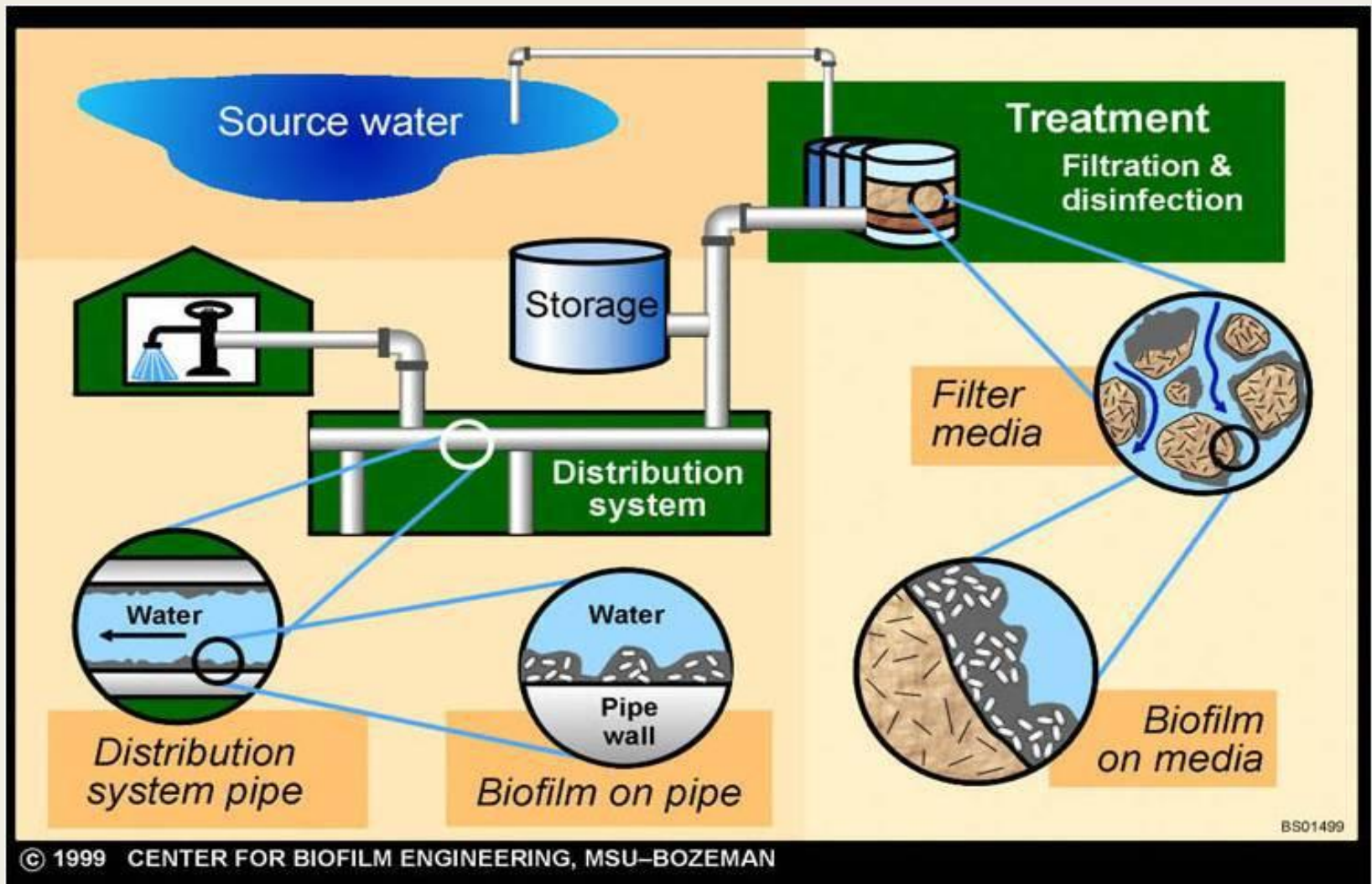
Water Treatment Plant Process

-Surviving the Treatment Process such as Filter Break-Through

-Ineffective Pre-Post Disinfection/Oxidation

Distribution Maintenance/Management

-Infiltration/Contamination from Line Breaks

-Insufficient water flow or inadequate tank turnover

-Insufficient CL2 residuals

POTABLE WATER IS NOT STERILE!!!!!

Treatment Process from Raw Source to Distribution System

Source water

Treatment
Filtration & disinfection

Storage

Filter media

Distribution system

Water

Distribution system pipe

Water

Pipe wall

Biofilm on pipe

Biofilm on media

BS01499

© 1999   CENTER FOR BIOFILM ENGINEERING, MSU–BOZEMAN
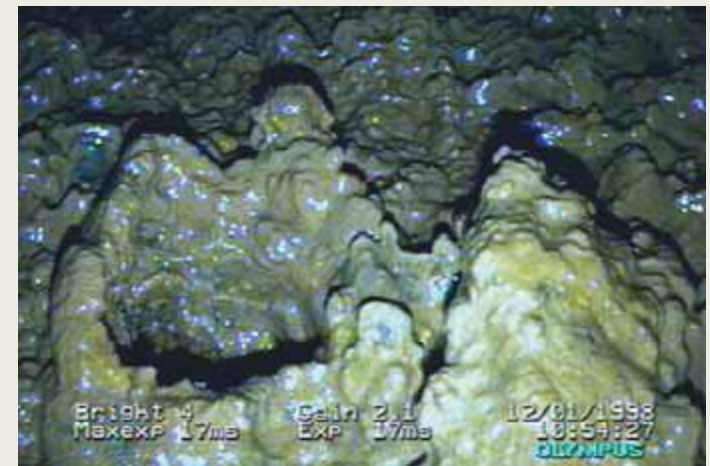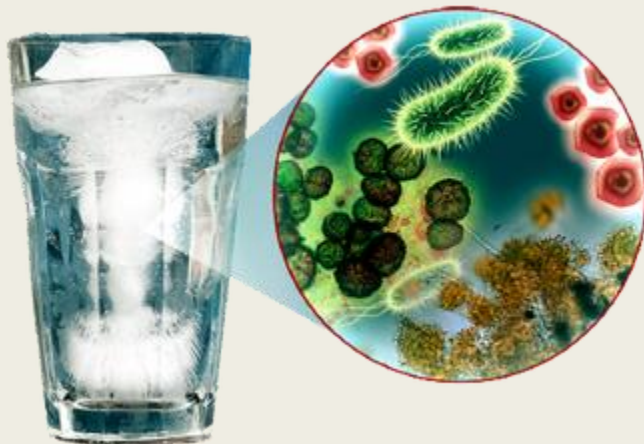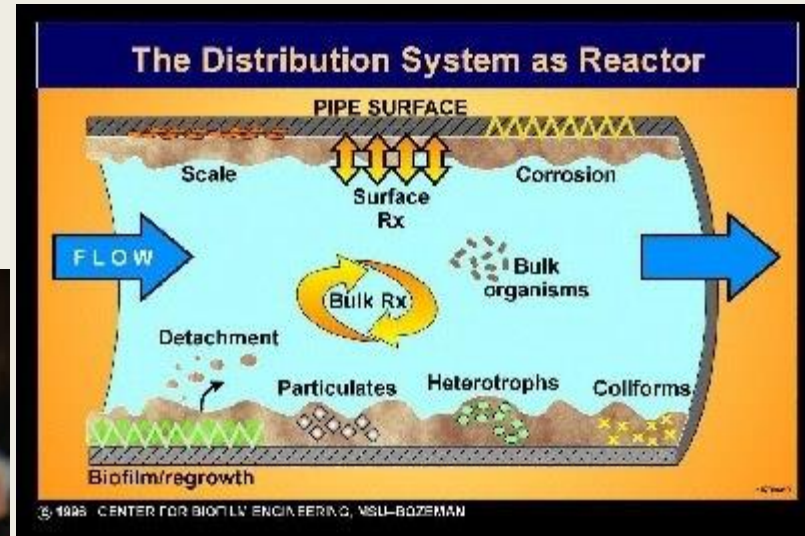
Bacteria that can cause or be present in Bio-Films

- *Sulfate Reducing Bacteria (SRB)

- *Iron-Related Bacteria (IRB)

- *Slime Bacteria

- Nitrifying Bacteria

- De-Nitrifying Bacteria

- Heterotopic Aerobic Bacteria

- Blue-Green Algae Detection

- Fluorescing Pseudomonas

- Pool and Spa Bacteria Detecting

Recognizing the Types of Bio-Film

BIO-Formation (Bio-Films)
Identifying Biological Corrosion
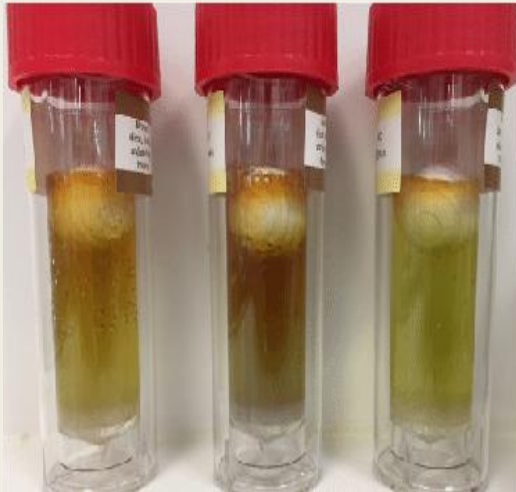
Testing for Bio-Films
BARTS Bio-Detectors/HPC

Testing for Bio-Films
Most Common BARTS Bio-Detectors in Water Systems

Testing for Bio-Films
BART Test (Positive)

"Cause" and "Effect" of Bio-Films in Water Systems

Cause:

- -Bacteria Adhere to the surfaces in aqueous environments and begin to "Excrete" a slimy glue-like substance that can/will anchor them to all kinds of material such as metals, plastics, filter media and concrete. (Biofilm Engineering Dept. Montana State Univ.)

"Cause" and "Effect" of Bio-Films in Water Systems

■ **Effect:**

1. Increased CL2 Demand throughout the plant and system

2. Discolored Water/Aesthetics Problems

3. Taste/Odor Complaints (metallic, Chlorine smell, Sulfur,)

4. Depleted CL2 residuals (Long periods of flushing until CL2 residuals Are adequate

5. Elevated TTHM/HAA5 Spikes are sample sites

Operational Factors that "Control" the Growth of Biofilm

- ☐ <u>Proactive corrosion control</u>
  - Corrosion in drinking water systems can be controlled by adjusting pH, alkalinity or by introducing corrosion inhibitors phosphates (orthophosphate, polyphosphate) or Bio-Penetrants

- ☐ Preventing Sedimentation and scale formation
  - Either by Flushing, pH control, or sequestration utilizing a "Ortho/Poly Phosphate"

- ☐ Implementation of a flushing program
  - Use of Bio-Penetrants
  - high velocity (~5 feet per second [fps]
  - lower velocity (1 to 3 fps)

- ☐ Improving Water Treatment Process
  - • addition of a Pre-Oxidant (Permanganate, Peroxide etc..)
  - • Enhanced coagulation
  - • Filter Evaluation and Remediation
  - • Activated Carbon Treatment
  - • Adding Corrosion Inhibitors (Poly/Ortho Phosphates
  - • Use of BIO-Penetrant or Phosphate w/Bio-penetrant added
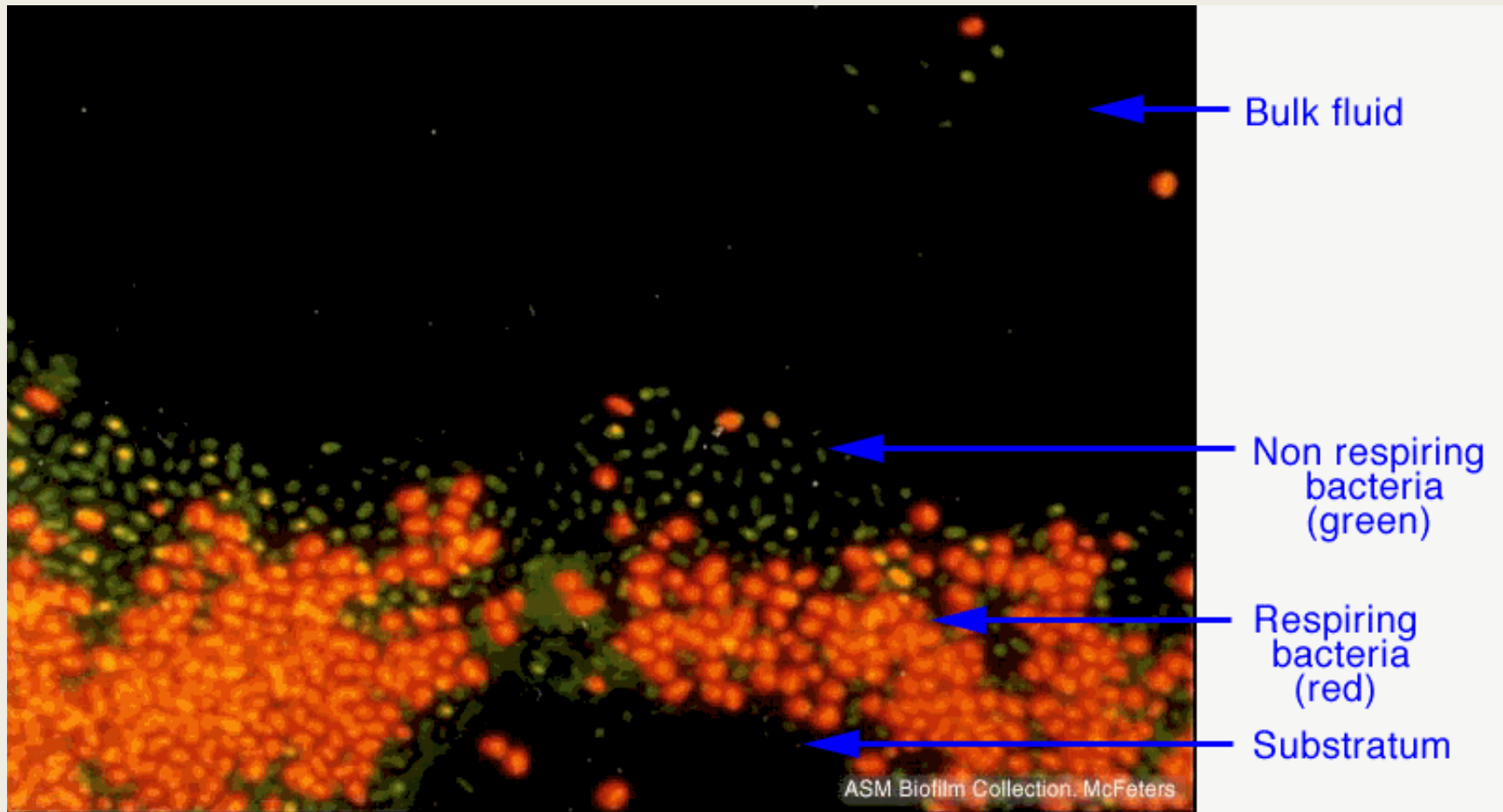
Actual Bio-Film in a distribution System

Protection of Bacteria Deeper in the Bio-Film Against Disinfectants
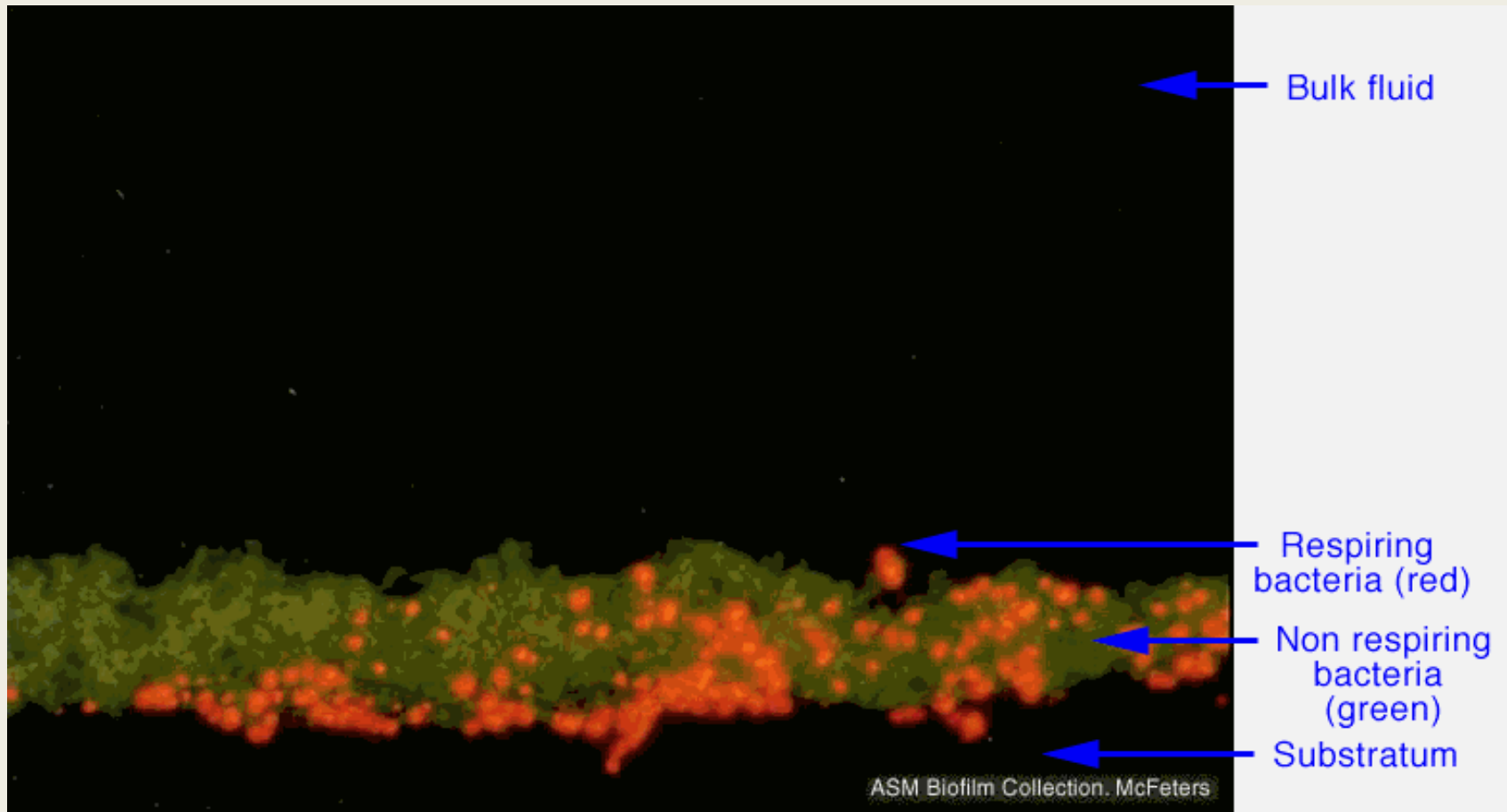
UNTREATED BIO-FILM
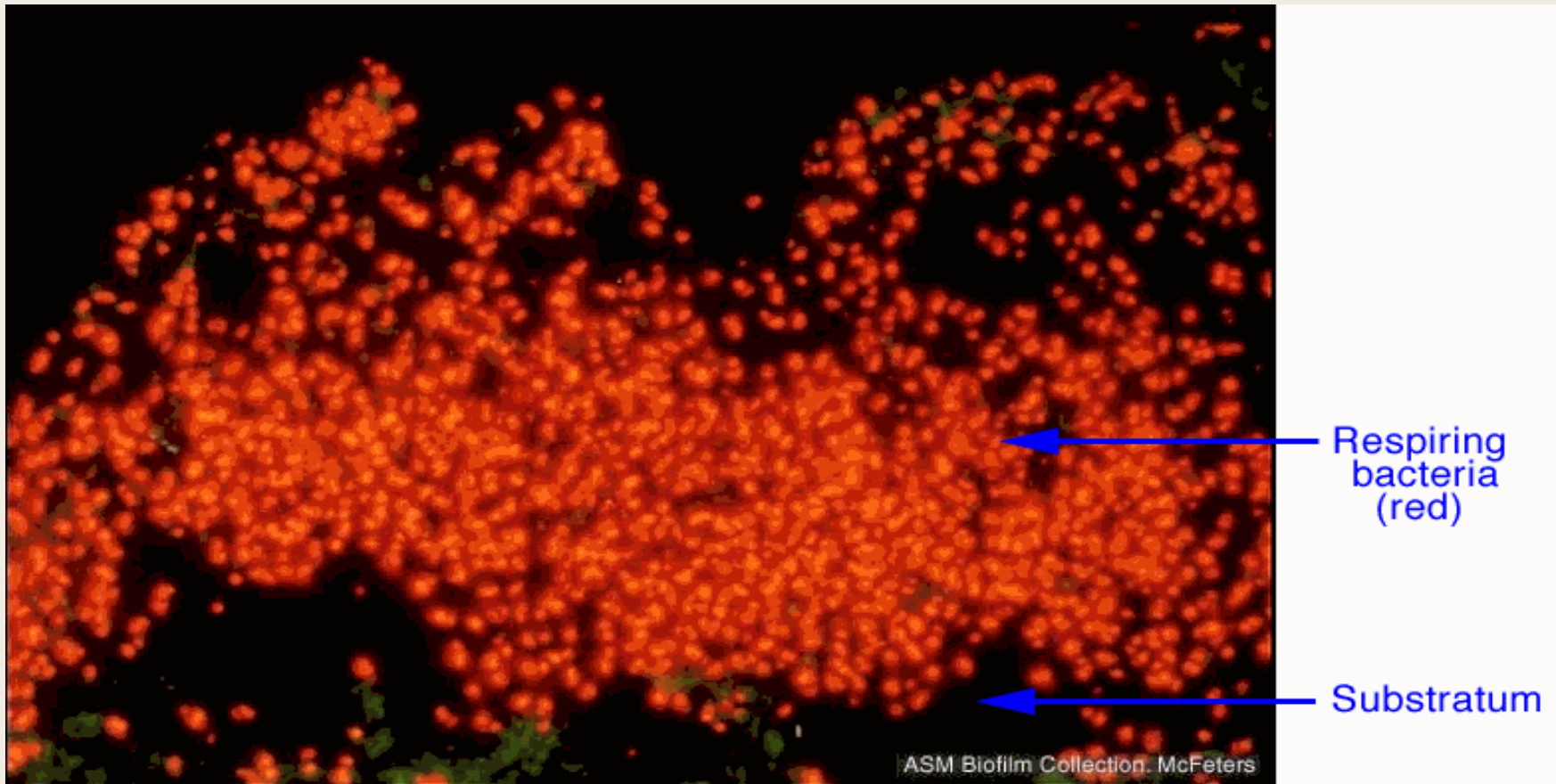
Protection of Bacteria Deeper in the Bio-Film against Disinfectants
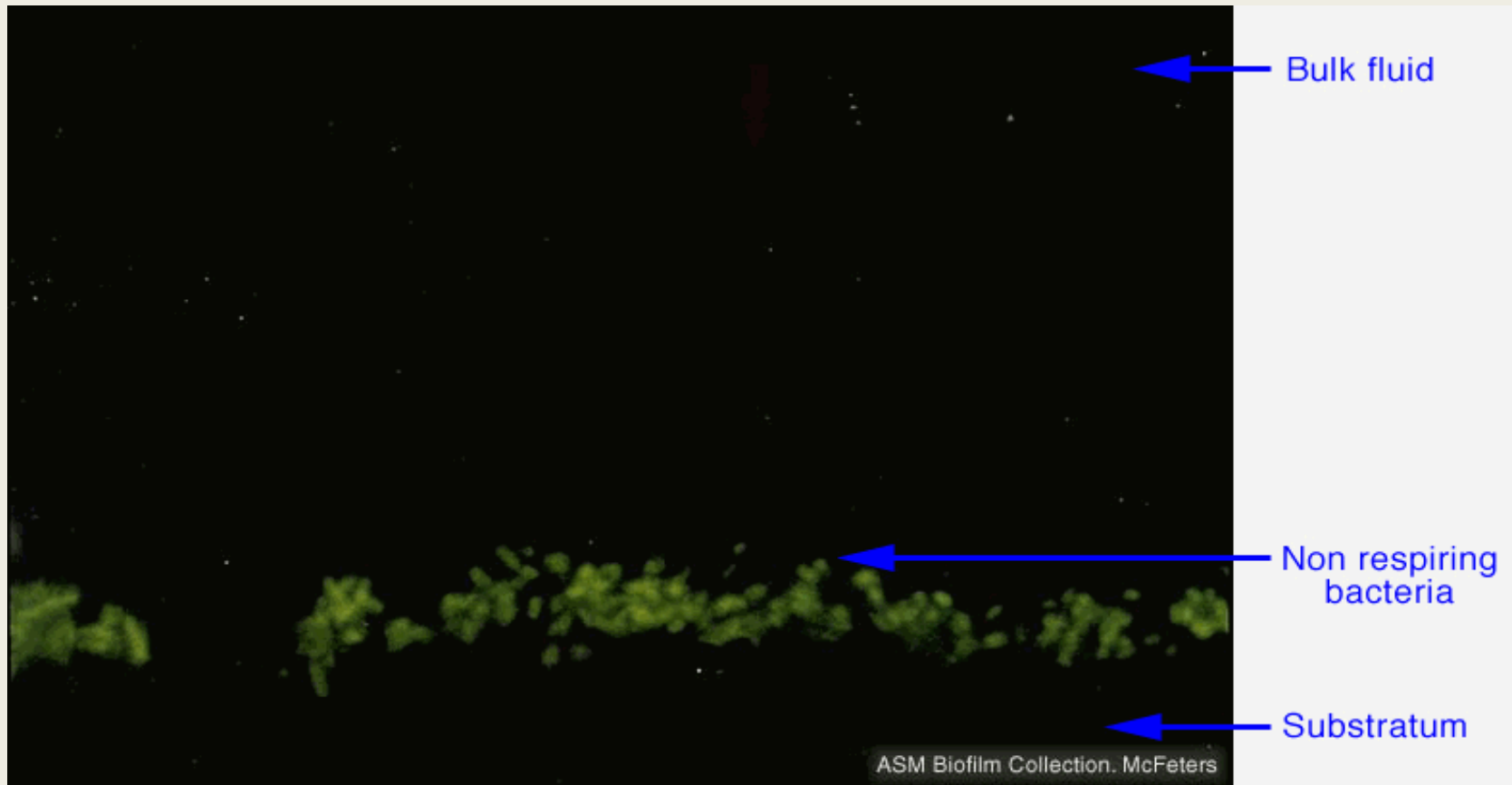
Bio-Film after Treatment CL2 @ 100ppm 48 hrs.

Protection of Bacteria Deeper in the Bio-Film Against Disinfectants

Bio-Film after 24 hrs. exposure to 5 ppm CL2, 1ppm Blended Phosphate and 5 ppm Bio-Penetrant

Protection of the Bacteria Deeper in the Bio-Film Against Disinfectants

Bio-Film after 96 hrs. exposed to 3 ppm Cl2, 1ppm Blended Phosphate and 5 ppm Bio-Penetrant
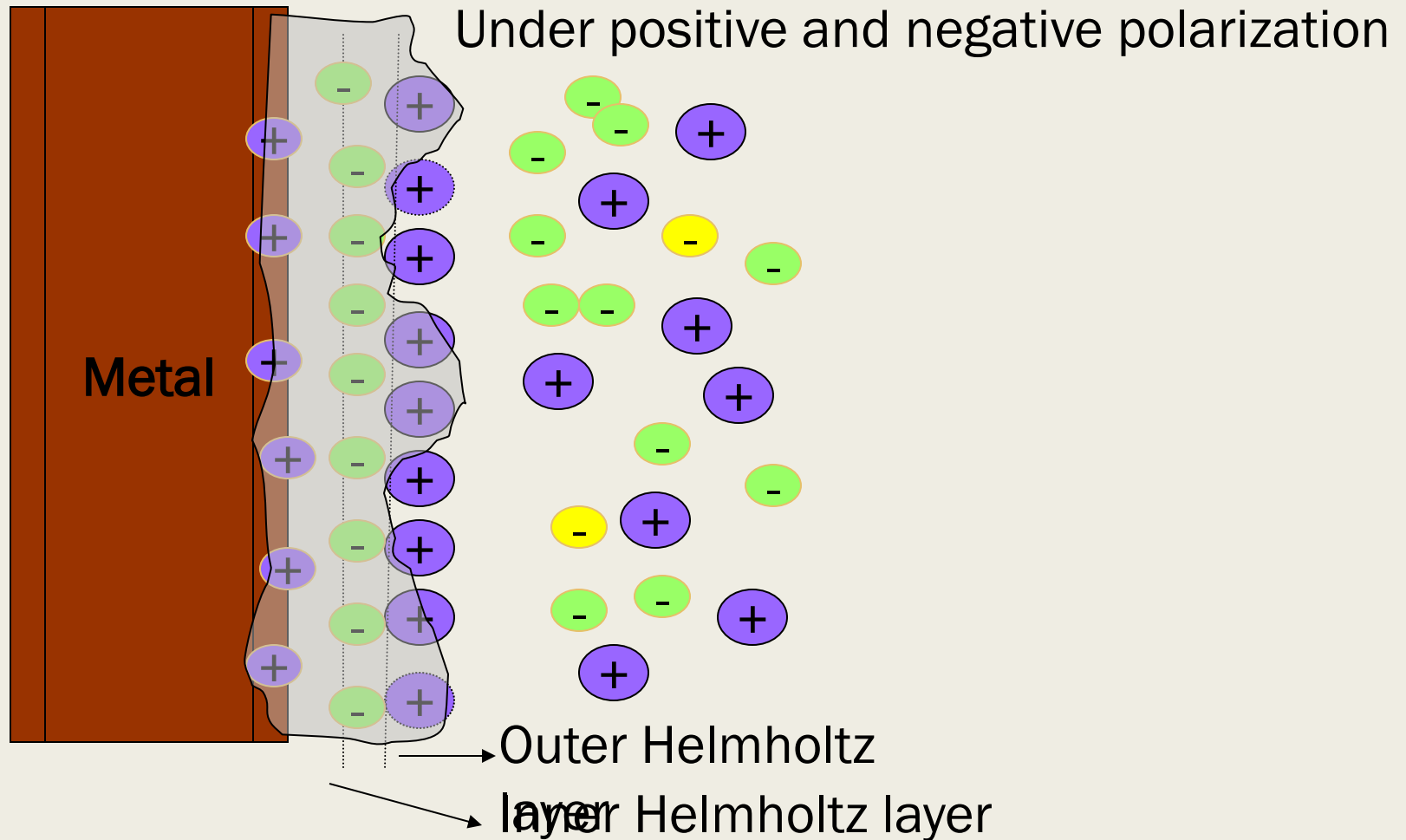
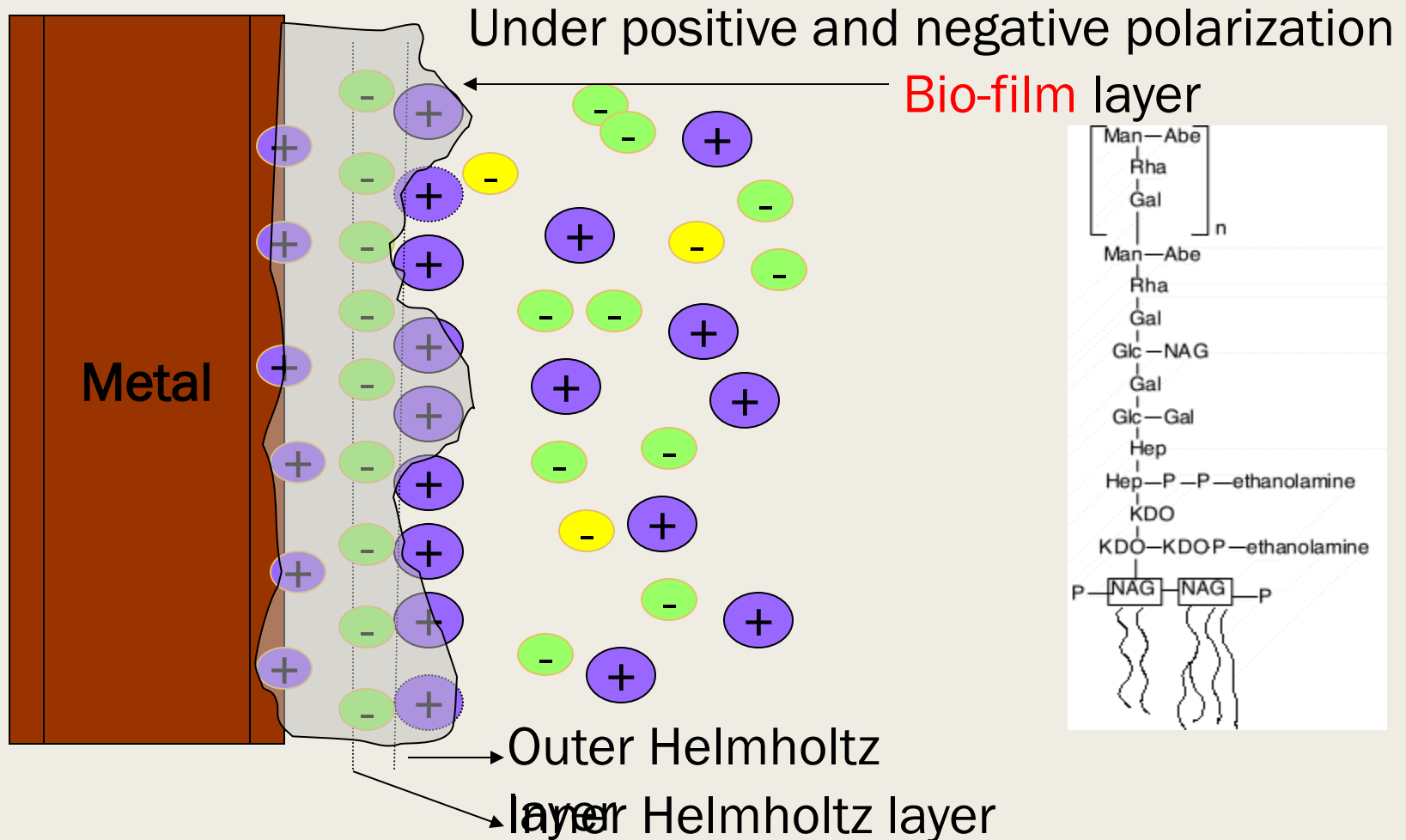# Theory of BIO-Penetration utilizing Phosphates

- **Bio-film** comprised of anion/cation mix

- Source of metal component is the bulk water in which biofilm is found

- Polyphosphate extracts metal ions from biofilm matrix, leaving a gap

- Chlorine is now able to enter the gap in **Bio-Film** to kill bacteria beneath film wall

- Bio-Penetrant is used to enhance Disinfection without increasing CL2.

Schematic of Electrical layer

Under positive and negative polarization

Metal

Outer Helmholtz

layer Helmholtz layer

Schematic of Bio-film Adhesion

Under positive and negative polarization

Bio-film layer

Metal

Outer Helmholtz layer

Inner Helmholtz layer

Schematic of Bio-film Adhesion

Under positive and negative polarization

Bio-film layer

Metal

Outer Helmholtz layer

Inner Helmholtz layer

Schematic of Bio-film Adhesion

Under positive and negative polarization

Bio-film layer

Metal

Outer Helmholtz layer

Inner Helmholtz layer

Schematic of Bio-film Adhesion

Under positive and negative polarization

Bio-film layer

Metal

Outer Helmholtz layer

Inner Helmholtz layer

[Man—Abe]
Rha
Gal
]n
Man—Abe
Rha
Gal
Glc—NAG
Gal
Glc—Gal
Hep
Hep—P—P—ethanolamine
KDO
KDO—KDO·P—ethanolamine
P—NAG—NAG—P

BIO-FILM MANAGEMENT FACT SHEET

HAWKINS

- **<u>Deciding if a problem exists</u>**

    How: Monitoring Water Quality Parameters/Complaints (e.g., taste and odor, DBP's Spikes, high CL2 residual demand, HPC or BART's)

- **<u>Assessing bio-film growth</u>:**

    How: Developing and executing a bio-film sampling plan considering sample types, sample location, bio-film analytical/Testing methods, data analysis (This includes <u>All ENTITIES OF THE SYSTEM</u>)

- **<u>Factors affecting bio-film growth analysis</u>**

    How: Reviewing water quality and distribution system operation data (e.g., pipe materials, system hydraulics, pH, temperature, CL2 residual, complaints)

- **<u>Bio-film management strategies</u>**

    How: Developing a plan of "Action"

- Target identified bio-film with strategies for reduction/control

- Targeted plan can be tailored toward elimination of dominant bacteria or other bacteria of interest identified by testing results

Monitoring for Bio-Film/Bacteriological Presence
"*REGROWTH*"

- Biological Corrosion does not *"GO AWAY"*

- Water Professionals have an ongoing battle to control Bacteriological Presence and *re-growth*

- Monitoring Techniques include:
  - *CL2 residuals (Free and Total)*
  - *Customer Complaints (Including CL2 odors/tastes)*
  - *Periodic BART Testing*
  - *HPC (Heterotrophic Plate Counts) testing*
  - *Visual identification of water quality when flushing*
  - *Observance of Pipe sections or coupons*

Conclusion

■ Questions/Answer

"THANK YOU FOR YOUR ATTENTION"

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